MINISTRY OF EDUCATION, SINGAPORE
in collaboration with
UNIVERSITY OF CAMBRIDGE LOCAL EXAMINATIONS SYNDICATE
General Certificate of Education Ordinary Level

CANDIDATE NAME

CENTRE NUMBER | S | | | | |

INDEX NUMBER | | | | |

Paper 3 Chemistry

October/November 2017

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, index number and name on all the work you hand in.
You may use an HB pencil for any diagrams, graphs, tables or rough working.
Write in dark blue or black pen.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.
Write your answers in the spaces provided on the question paper.

Section B
Answer any **two** questions.
Write your answers in the spaces provided on the question paper.

A copy of the Data Sheet is printed on page 15.
A copy of the Periodic Table is printed on page 16.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Section A

Answer **all** the questions in the spaces provided.

1 Substances can be classified as elements, compounds or mixtures.

When completed, Table 1.1 describes four substances.

Complete the table.

Table 1.1

substance	classification (element, compound or mixture)	atoms within this substance
hydrogen chloride	compound	hydrogen and chlorine
water		
steel		
air		

[6]

2 Elements in the same group of the Periodic Table often show trends in physical properties and similarities in chemical properties.

(a) Name a group in the Periodic Table and briefly describe a trend in a physical property shown on moving down this group.

name of group .....

trend in physical property .....

.....

.....

[2]

(b) Name a group in the Periodic Table and briefly describe a chemical property similar for all elements in this group.

name of group .....

chemical property .....

.....

.....

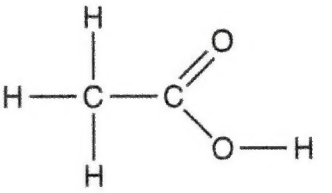
[2]

3 A homologous series is a group of compounds that have similar chemical properties and the same general formula.

When completed, Table 3.1 shows three different homologous series and the name and structure of a member of each series.

Complete the table. Show all the bonds in the structures.

Table 3.1

homologous series	member of series	structure
alcohols	ethanol	
	ethane	
carboxylic acids		

[4]

4 In 25 cm^3 of an aqueous solution, there is 5.3 g of sodium carbonate, Na_2CO_3.

(a) Calculate the concentration of the solution in g/dm^3 **and** in mol/dm^3.

[Relative atomic masses, A_r: C, 12; O, 16; Na, 23]

concentration = ... g/dm^3

concentration = ... mol/dm^3
[2]

(b) (i) Write a balanced chemical equation for the reaction between hydrochloric acid and sodium carbonate.

..... [2]

(ii) Calculate the number of moles of hydrochloric acid needed to react completely with 25 cm^3 of sodium carbonate solution.

number of moles = ... [1]

5 **(a)** Sodium hydroxide is an alkali. Give **two** chemical properties of all alkalis.

1. .....

.....

2. .....

.....

[2]

(b) Many plants grow better in alkaline soils than in acidic soils. Name and give the chemical formula of the ion that causes soils to be alkaline.

name .....

formula .....

[1]

(c) Explain how the acidity in soils can be removed and how the pH of the soil changes during the removal.

.....

.....

..... [2]

6 **(a)** Describe a test for the sulfate ions in dilute sulfuric acid.

test .....

.....

result .....

[2]

(b) Use the following information to suggest the steps needed to prepare by precipitation pure lead(II) sulfate, starting from powdered lead(II) oxide.

- lead(II) sulfate is insoluble in water
- lead(II) oxide is insoluble in water
- lead(II) nitrate is soluble in water

.....

.....

.....

.....

.....

..... [3]

7 Four students worked separately, each with equal concentrations of dilute sulfuric acid but with different metals. The metals were labelled as **metal 1**, **metal 2**, **metal 3** and **metal 4**.

Each student added 0.5 mol of powdered metal to an excess of the acid in a large conical flask and immediately placed their flask on a top-pan balance.

The students recorded the total mass of their flask and its contents regularly over the next 280 seconds. They then calculated the loss in mass of their flask and its contents over time.

The results of their investigations are displayed in Fig. 7.1.

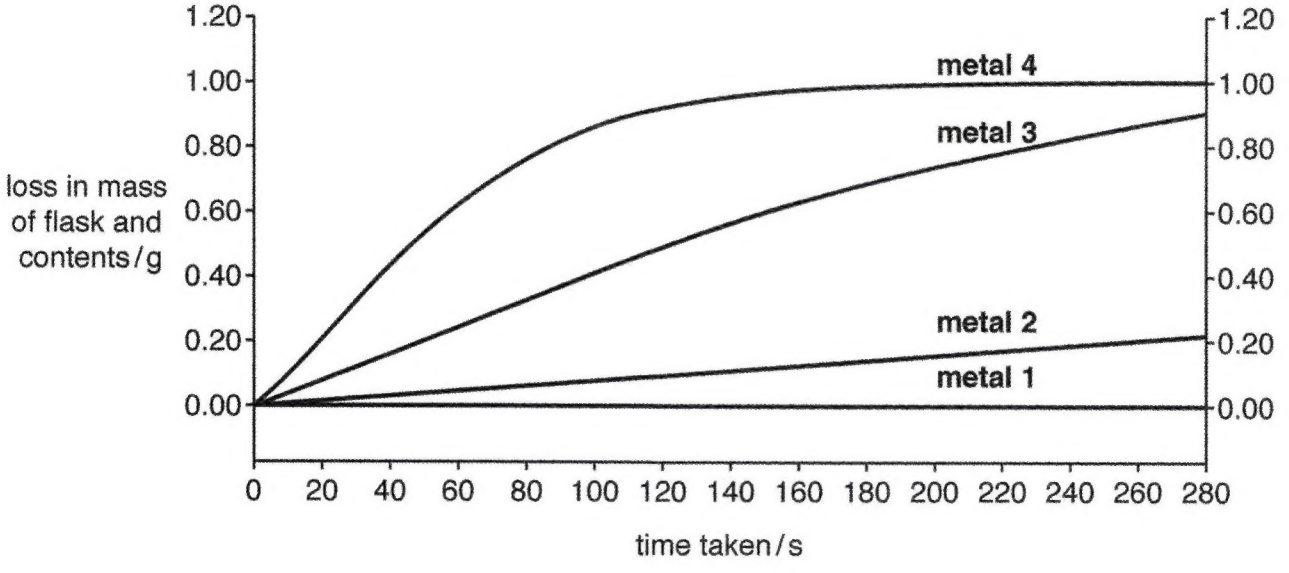


Fig. 7.1

(a) Explain why the total mass of the flasks and their contents decreased in three of these investigations.

.....

..... [1]

(b) State which of the metals that reacted was the first to stop reacting.

..... [1]

(c) **(i)** State which metal did not appear to react with the acid.

..... [1]

(ii) Describe where this metal is placed, relative to hydrogen, in the reactivity series.

..... [1]

(d) (i) Suggest the names of any **two** of these metals and complete Table 7.1.

Table 7.1

label of metal (e.g. **metal 1**)	name of metal

[2]

(ii) Write a balanced chemical equation for the reaction of **one** of your named metals in Table 7.1 with sulfuric acid.

Include state symbols.

..... [3]

8 Fig. 8.1 involves compound **C**, a metal chloride.

You will need the following information to identify **C**.

- compound **C** has the general formula **X**Cl_2
- **X** represents a metal in Group II of the Periodic Table
- relative atomic masses, A_r: Be, 9; Mg, 24; Cl, 35.5; Ca, 40; Sr, 88; Ba, 137

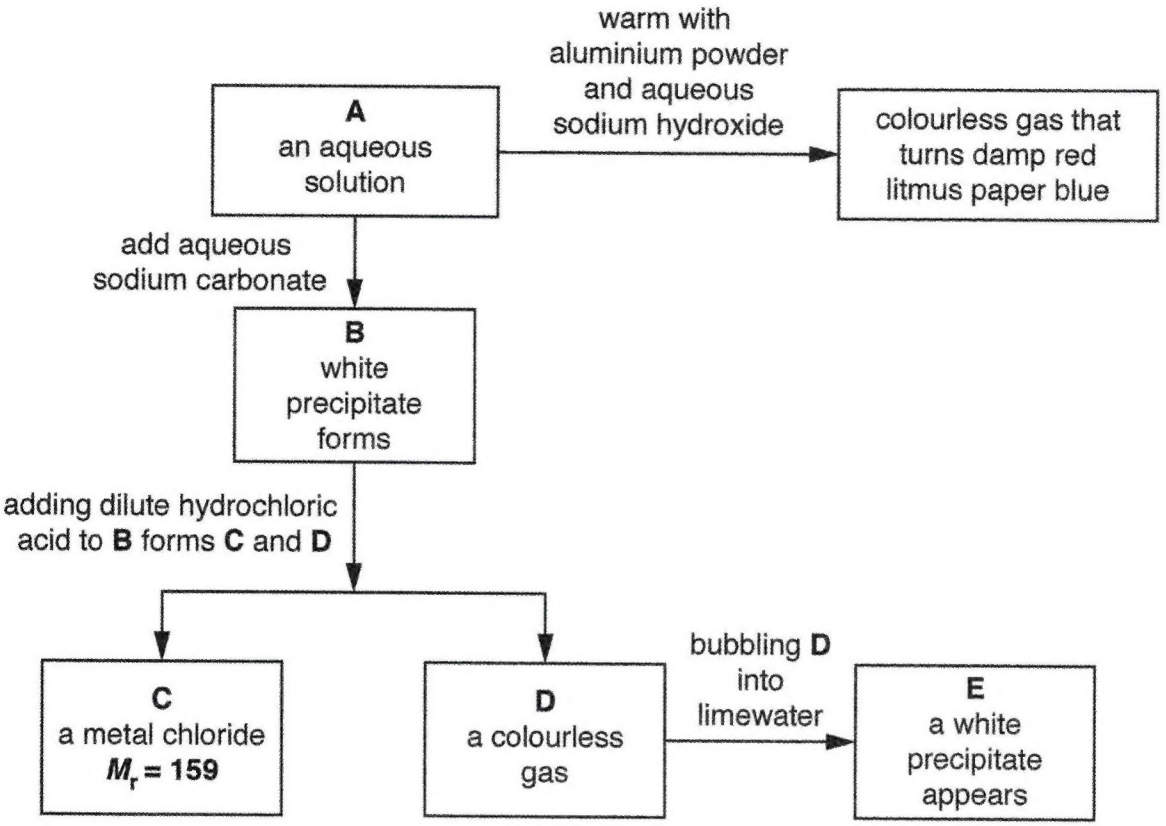


Fig. 8.1

(a) Identify and write either the name or chemical formula for each of **E**, **D**, **C**, **B** and **A**.

E .....

D .....

C .....

B .....

A .....

[5]

(b) Write a balanced chemical equation for any **one** of the reactions in Fig. 8.1.

..... [2]

Section B

Answer any **two** questions in this section.

Write your answers in the spaces provided.

9 **(a)** The relative atomic mass of an atom of boron is 11.

(i) Define the term *relative atomic mass* and explain what this tells you about the mass of an atom of boron.

.....

.....

.....

.....

.....

..... [3]

(ii) Most atoms of boron have the symbol $^{11}_{5}B$.

Explain what the number 11 and the number 5 tell you about the particles in an atom of boron.

.....

.....

.....

.....

..... [2]

(iii) State why other atoms of boron have different masses from the more commonly occurring boron atoms.

.....

..... [1]

(b) Zinc can be extracted from its oxide using carbon, but boron is extracted from its oxide using magnesium.

(i) Suggest why magnesium, but not carbon, is used to extract boron from boron oxide.

.....

.....

.....

.....

..... [2]

(ii) Calculate the mass of magnesium needed to manufacture 10 kg of boron.

$$B_2O_3 + 3Mg \rightarrow 3MgO + 2B$$

[Relative atomic masses, A_r: B, 11; Mg, 24]

mass of magnesium = ... kg [2]

10 **(a)** Describe the process and conditions by which alkenes are manufactured from long chain hydrocarbons. A chemical equation is **not** required.

.....

.....

.....

.....

..... [3]

(b) Ethene is an alkene.

Suggest, using a 'dot and cross' diagram, the electronic structure of ethene, C_2H_4.

[Proton (atomic) numbers: H, 1; C, 6]

[3]

(c) **(i)** Alkenes burn in oxygen.

Write a balanced chemical equation for the complete combustion of any alkene.

..... [2]

(ii) Use your equation to determine the volume of gas formed **at room temperature and pressure** when 100 cm^3 of this alkene burns completely in oxygen.

[The volume of one mole of any gas is 24 dm^3 at room temperature and pressure.]

volume of gas = ... cm^3 [2]

11 (a) (i) State why coating iron with grease prevents iron from rusting.

.....

.....

.....

.....

..... [2]

(ii) Describe a laboratory investigation that can be used to decide which of **two** different alloys of iron is more resistant to rusting.

You are provided with the two alloys as very thin metal foils.

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..... [4]

(b) Iron(III) chloride is formed when iron is heated in chlorine gas.

(i) Write a balanced chemical equation for this reaction.

..... [2]

(ii) State, with reasons, whether iron is being oxidised or reduced or neither of these.

.....

.....

.....

.....

..... [2]

39. (B)

Cracking involves the breakdown of long chain hydrocarbons to produce alkenes and hydrogen.

∴ X is an alkene (C_nH_{2n}). Based on the equation given, we can calculate the number of carbon and hydrogen atoms in X:

$$\text{Number of carbon atoms in X} = \frac{17-2(2)-3}{2}$$
$$= 5$$

$$\text{Number of hydrogen atoms in X} = \frac{36-2(4)-6-2}{2}$$
$$= 10$$

∴ X is C_5H_{10}.

An alkene undergoes addition reaction with aqueous bromine. The reddish-brown bromine turns colourless as it reacts with the alkene.

EXAM TIP:

The general formula of alkanes is C_nH_{2n+2} and the general formula of alkenes is C_nH_{2n}.

40. (D)

Ethanol is an alcohol, with the functional group –OH (does not contain a C = O bond). Ethanol is oxidised by potassium manganate(VII) to form ethanoic acid. Ethanol burns completely to produce carbon dioxide (not carbon monoxide) and water.

October/November 2017 Paper 3

Section A

1.

substance	classification (element, compound or mixture)	atoms within this substance
hydrogen chloride	compound	hydrogen and chlorine
water	**compound**	**hydrogen and oxygen**
steel	**mixture**	**iron and carbon**
air	**mixture**	**nitrogen and oxygen**

EXAM TIP:

An element is a substance that cannot be broken down into simpler substances through any chemical or physical means. A compound is a substance that contains two or more elements which are chemically combined in a fixed ratio. A mixture consists of two or more substances that are mixed together.

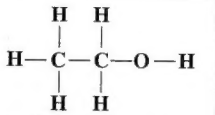
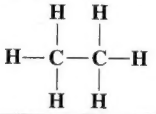
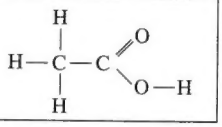
2. **(a)** name of group: Group VII

trend in physical property: The boiling points of the elements in Group VII increase down the group.

(b) name of group: Group I

chemical property: All Group I elements react violently with water.

3.

homologous series	member of series	structure
alcohols	ethanol	
alkanes	ethane	
carboxylic acids	**ethanoic acid**	

EXAM TIP:

The general formula of alcohols is $C_nH_{2n+1}OH$; the general formula of alkanes is C_nH_{2n+2}; the general formula of alkenes is C_nH_{2n}.

4. **(a)** Concentration of solution in g / dm^3

$$= 5.3 \div \frac{25}{1000}$$

$$= \underline{212 \text{ g / dm}^3}$$

Molar mass of $Na_2CO_3 = 2(23) + 12 + 3(16)$

$$= 106$$

Concentration of solution in mol / dm^3

$$= 212 \div 106$$

$$= \underline{2 \text{ mol / dm}^3}$$

EXAM TIP:

$$\text{Concentration of solution in g / dm}^3 = \frac{\text{Mass of compound (g)}}{\text{Volume of solution (dm}^3\text{)}};$$

$$\text{Concentration of solution in mol / dm}^3 = \frac{\text{Concentration of solution in g / dm}^3}{\text{Molar mass of reactant in g / mol}}$$

(b) **(i)** $2HCl + Na_2CO_3 \rightarrow 2NaCl + CO_2 + H_2O$

(ii) Number of moles of $Na_2CO_3 = 2 \times \frac{25}{1000}$

$$= 0.05 \text{ mol}$$

1 mole of Na_2CO_3 reacts with 2 moles of HCl.

Number of moles of HCl = 0.05 × 2

$$= \underline{0.1 \text{ mol}}$$

EXAM TIP:

Number of moles = concentration × volume

5. **(a)** 1. Alkalis react with ammonium salts to produce salt, ammonia and water.

2. Alkalis undergo neutralisation with acids to produce salt and water.

(b) name: hydroxide

formula: OH^-

(c) To remove the acidity in soils, add calcium hydroxide to the soil. Since calcium hydroxide is alkaline, it neutralises acid in the soil, thereby increasing the pH of the soil.

EXAM TIP:

When the soil becomes less acidic or more alkaline, the pH of the soil increases.

6. **(a)** test: Add barium nitrate to dilute sulfuric acid.

result: A white precipitate formed indicates the presence of sulfate ions.

(b) Add the powdered lead(II) oxide to nitric acid to form lead(II) nitrate. Add sodium sulfate solution (or sulfuric acid) to the lead(II) nitrate formed. A white precipitate of lead(II) sulfate will be formed. Filter the mixture to obtain lead(II) sulfate. Wash the salt with distilled water and dry with filter paper.

EXAM TIP:

Filtration of the mixture is required to separate the lead(II) sulfate from the solid-liquid mixture.

7. **(a)** Metals react with dilute sulfuric acid to produce hydrogen gas, which escapes from the flasks and therefore the total mass of the flasks and their contents decreased.

(b) Metal 4

EXAM TIP:

When the gradient of the graph becomes constant, it indicates that the metal has stopped reacting with the acid.

(c) **(i)** Metal 1

EXAM TIP:

The constant gradient of the graph for metal 1 indicates that there was no loss in mass of the flask and contents, hence there was no reaction between metal 1 and the acid.

(ii) Metal 1 is placed below hydrogen in the reactivity series.

(d) **(i)** Any two of the following:

label of metal (e.g. **metal 1**)	name of metal
metal 1	**copper**
metal 2	**iron**
metal 3	**zinc**
metal 4	**magnesium**

(ii) Any one of the following:

$Mg(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2(g)$

$Fe(s) + H_2SO_4(aq) \rightarrow FeSO_4(aq) + H_2(g)$

$Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$

8. **(a)** **E** Calcium carbonate or $CaCO_3$

D Carbon dioxide or CO_2

C Strontium chloride or $SrCl_2$

B Strontium carbonate or $SrCO_3$

A Strontium nitrate or $Sr(NO_3)_2$

EXAM TIP:

A gas that turns damp red litmus paper blue is alkaline. Carbon dioxide is a colourless gas that produces a white precipitate when bubbled into limewater.

(b) Any one of the following:

$Sr(NO_3)_2 + Na_2CO_3 \rightarrow SrCO_3 + 2NaNO_3$

$SrCO_3 + 2HCl \rightarrow SrCl_2 + CO_2 + H_2O$

$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

Section B

9. **(a)** **(i)** Relative atomic mass refers to the average mass of an atom compared with $\frac{1}{12}$ of the mass of a carbon-12 atom. An atom of boron is eleven times heavier than $\frac{1}{12}$ of a carbon-12 atom.

(ii) There are 5 protons, 5 electrons and 6 neutrons in an atom of boron.

EXAM TIP:

The proton number is shown on the bottom left of the chemical symbol while the nucleon number is on the top left.

(iii) Isotopes of boron exist, which have the same number of protons but different numbers of neutrons, and hence different masses.

(b) **(i)** Magnesium is more reactive than boron, thus it displaces boron from boron oxide. On the other hand, carbon is less reactive than boron, thus it cannot displace boron from boron oxide. Therefore, carbon cannot be used to extract boron from boron oxide.

EXAM TIP:

The more reactive element displaces the less reactive element in a reaction.

(ii) 10 kg = 10 000 g

Number of moles of boron

$= \frac{10\ 000}{11}$

= 909.09 mol (to 5 s.f.)

3 moles of magnesium react to form 2 moles of boron.

Number of moles of magnesium

$= \frac{3}{2} \times 909.09$

= 1363.6 mol (to 5 s.f.)

Mass of magnesium needed

= 1363.6 × 24

= 32 726.4 g

= <u>32.7 kg</u> (to 3 s.f.)

EXAM TIP:

Number of moles of substance = $\frac{\text{Mass}}{\text{Molar mass}}$

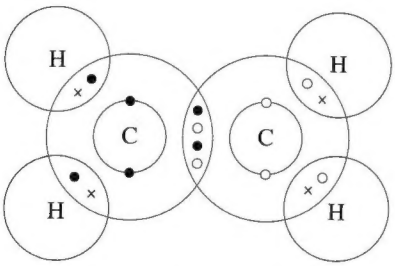
10. (a) The process is cracking, where long chain hydrocarbons are cracked to form smaller alkenes. This is done by passing the long chain hydrocarbons over a catalyst, consisting of aluminium oxide and silicon dioxide, at a temperature of about 600 °C. This forms a mixture of smaller alkanes, alkenes and hydrogen.

EXAM TIP:

Large hydrocarbons can be broken down into smaller molecules through cracking.

(b)

- • electron of C (on the left)
- ○ electron of C (on the right)
- × electron of H



EXAM TIP:

The C and H atoms in ethene are bonded by covalent bonds.

(c) (i) $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$

EXAM TIP:

Complete combustion of an alkene produces carbon dioxide and water.

(ii) Since the reaction is carried out at room temperature and pressure, the volume ratio of the reactants and products will be equal to their molar ratio.

From the chemical equation, 1 mol of C_2H_4 produces 2 mol of CO_2.

∴ 100 cm^3 of C_2H_4 will produce

2 × 100 = <u>200 cm^3</u> of CO_2.

11. (a) (i) When iron is exposed to the surroundings, the presence of oxygen and water causes it to rust. Coating iron with grease prevents it from coming into contact with oxygen and water, thereby preventing it from rusting.

EXAM TIP:

Rusting can be prevented by painting or covering the metal with a layer of oil.

(ii) Cut the two metal foils of alloys such that they are of the same mass and record this mass. Then, place the two metal foils into two separate test-tubes respectively. Leave both test-tubes in the same environment where the temperature is the same, with the same amount of water and oxygen. One week later, remove the metal foils from the test-tubes and measure their respective masses and record them. Compare the increase in mass of each metal foil; the one that has a smaller increase in mass is more resistant to rusting.

EXAM TIP:

Iron corrodes in the presence of water and oxygen to form rust.

(b) (i) $2Fe + 3Cl_2 \rightarrow 2FeCl_3$

(ii) Iron is being oxidised as the oxidation state increases from 0 in Fe to +3 in $FeCl_3$.

EXAM TIP:

After the reaction, if the oxidation state of iron increases, iron is being oxidised. If the oxidation state of iron decreases, iron is being reduced.